CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, LAUNCH CONTROL CENTER
(John F. Kennedy Space Center)
LCC Road, East of Kennedy Parkway North
Cape Canaveral
Brevard
Florida

HAER FL-8-11-A
FL-8-11-A

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
SOUTHEAST REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
100 Alabama St. NW
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39,
LAUNCH CONTROL CENTER (John F. Kennedy Space Center)
HAER No. FL-8-11-A

Location: LCC Road, east of Kennedy Parkway North
John F. Kennedy Space Center
Cape Canaveral
Brevard County
Florida

U.S.G.S. 7.5. minute Orsino, Florida, quadrangle,
Universal Transverse Mercator coordinates:
17.534260.3161900

Date of Construction: 1963-1965

Architect: Martin Stein, project architect
URSAM (Max Urbahn [architectural]; Roberts and Schaefer [structural]; Seelye, Stevenson, Value and Knecht [civil, mechanical and electrical]; and Moran, Proctor, Mueser and Rutledge [foundations], New York

Builder: Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman, Inc (all based in California)

Present Owner: National Aeronautics and Space Administration (NASA)
Kennedy Space Center, FL 32899-0001

Present Use: Aerospace Facility-launch control center

Significance: The LCC was listed in the National Register of Historic Places (NRHP) on January 21, 2000. Originally nominated in the context of the Apollo Program, ca. 1961 through 1975, the LCC has since gained importance in the context of the Space Shuttle program, ca. 1969 to 2010. It is considered significant at the national level under NRHP Criterion A in the areas of Space Exploration and Communications, and under NRHP Criterion C in the area of Architecture. The Launch Control Center performs the vital operations integral to the prelaunch preparation and launch of NASA's manned space vehicles. Under Criterion C, the LCC, like typical examples of the International Style, is characterized by a lack of exterior ornament, a flat roof, ribbon windows on the north elevation, a skeletal structure of reinforced concrete, cantilevered upper floors, and an emphasis on horizontality.

Report Prepared by: Trish Slovinac, Architectural Historian
Archaeological Consultants, Inc.
8110 Blaikie Court, Suite A
Sarasota, Florida 34240

Date: January 2009

HISTORICAL INFORMATION

NASA's John F. Kennedy Space Center (KSC)

The John F. Kennedy Space Center is NASA's primary Center for launch and landing operations, vehicle processing and assembly, and related programs in support of manned space missions. It is located on the east coast of Florida, about 150 miles south of Jacksonville, and to the north and west of Cape Canaveral, in Brevard and Volusia Counties, and encompasses almost 140,000 acres. The Atlantic Ocean and Cape Canaveral Air Force Station (CCAFS) are located to the east, and the Indian River is to the west.

Following the launch of Sputnik I and Sputnik II, which placed Soviet satellites into Earth's orbit in 1957, the attention of the American public turned to space exploration. President Dwight D. Eisenhower initially assigned responsibility for the U.S. Space Program to the Department of Defense (DoD). The Development Operations Division of the Army Ballistic Missile Agency (ABMA), led by Dr. Wernher von Braun, began to focus on the use of missiles to propel payloads, or even a man, into space. The United States successfully entered the space race with the launch of the Army's scientific satellite Explorer I on January 31, 1958 using a modified Jupiter missile named Juno I .[1]

With the realization that the military's involvement in the space program could jeopardize the use of space for peaceful purposes, President Eisenhower established the National Aeronautics and Space Administration (NASA) on October 1, 1958 as a civilian agency with the mission of carrying out scientific aeronautical and space exploration, both manned and unmanned. Initially working with NASA as part of a cooperative agreement, President Eisenhower officially transferred to NASA a large portion of the Army's Development Operations Division, including the group of scientists led by Dr. Werner von Braun, and the Saturn rocket program.[2]

NASA became a resident of Cape Canaveral in 1958 when the Army Missile Firing Laboratory (MFL), then working on the Saturn rocket project under the direction of Kurt Debus, was transferred to the agency. Several Army facilities at CCAFS were given to NASA, including various offices and hangars, as well as Launch Complexes (LC) 5, 6, 26, and 34. The MFL was renamed Launch Operations Directorate (LOD) and became a branch office of Marshall Space Flight Center (MSFC). As LOD responsibilities grew, NASA granted the launch team increased status by making it a field center called the Launch Operations Center (LOC), and separating it from MSFC.

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[1] Charles D. Benson and William B. Faherty. *Gateway to the Moon. Building the Kennedy Space Center Launch Complex*. (Gainesville, University Press of Florida, 2001), 1-2.
[2] Benson and Faherty, *Gateway to the Moon*, 15.

In May 1961, President John F. Kennedy charged NASA and the associated industries to develop a space program that would surpass the Soviet program by landing a man on the moon by the end of the decade. With the new, more powerful Saturn V rocket and the stepped-up launch schedule, it was apparent that a new launch complex was required, and CCAFS, with 22 launch complexes, did not have the space for new rocket facilities. Merritt Island, an undeveloped area west and north of the Cape, was selected for acquisition, and in 1961 the Merritt Island Launch Area (MILA, which, with the LOC would become KSC) was born. In that year, NASA requested from Congress authority to purchase 80,000 ac of property, which was formally granted in 1962. The U.S. Army Corps of Engineers (ACOE) acted as agent for purchasing land, which took place between 1962 and 1964. NASA began gaining title to the land in late 1962, taking over 83,903.9 acres by outright purchase, which included several small towns, such as Orsino, Wilson, Heath and Audubon, many farms, citrus groves, and several fish camps. Negotiations with the State of Florida provided submerged lands, resulting in the acquisition of property identified on the original Deed of Dedication. Much of the State-provided land was located south of the Old Haulover Canal and north of the Barge Canal.

The American program to put a man in space and land on the Moon proceeded rapidly with widespread support. In November 1963, the LOC and MILA were renamed John F. Kennedy Space Center to honor the late President.[3] The space program was organized into three phases: Projects Mercury, Gemini, and Apollo. Project Mercury, initiated in 1958, was executed in less than five years. Begun in 1964, Project Gemini was the intermediate step toward achieving a manned lunar landing, bridging the gap between the short-duration Mercury flights and the long-duration missions proposed for the Apollo Program.[4]

Apollo, the largest and most ambitious of the manned space programs, had as its goal the landing of astronauts on the moon and their safe return to Earth. Providing the muscle to launch the spacecraft was the Saturn family of heavy vehicles. Saturn IB rockets were used to launch the early unmanned Apollo test flights and the first manned flight, Apollo 7, which carried astronauts on a ten-day earth orbital mission.[5]

Three different launch vehicles were used in Apollo: Saturn I, Saturn IB and Saturn V; and three different launch complexes were involved: LC 34 and LC 37 on CCAFS, and LC 39 on KSC (only LC 39 is still active). Altogether, thirty-two Saturn flights occurred (seven from LC 34, eight from LC 37, and seventeen from LC 39, including Skylab and the Apollo-Soyuz Test Project) during the Apollo era. Of the total thirty-two, fifteen were manned, and of the seven attempted lunar landing missions, six were successful. No major launch vehicle failures of either

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[3] Harry A Butowsky. *Reconnaissance Survey: Man in Space*. (Washington, D.C.: National Park Service, 1981), 5; Benson and Faherty, 146.
[4] Butowsky, 5.
[5] Butowsky, 5.

Saturn IB or Saturn V occurred. There were two major command/service module (CSM) failures, one on the ground (Apollo 1) and one on the way to the Moon (Apollo 13).[6]

The unmanned Apollo 4 mission, which lifted off on November 9, 1967, was the first Saturn V launch and the first launch from LC 39 at KSC. On July 21, 1969, the goal of landing a man on the moon was achieved when Apollo 11 astronauts Armstrong, Aldrin, and Collins successfully executed history's first lunar landing. Armstrong and Aldrin walked on the surface of the moon for twenty-two hours and collected 21 kilograms of lunar material. Apollo 17 served as the first night launch in December 1972. An estimated 500,000 people saw the liftoff which was the final launch of the Apollo Program.[7]

Skylab, an application of the Apollo Program, served as an early type of space station. With 12,700 cubic feet of work and living space, it was the largest habitable structure ever placed in orbit, at the time. The station achieved several objectives: scientific investigations in Earth orbit (astronomical, space physics, and biological experiments); applications in Earth orbit (earth resources surveys); and long-duration spaceflight. Skylab 1 orbital workshop was inhabited in succession by three crews launched in modified Apollo CSMs (Skylab 2, 3 and 4). Actively used until February 1974, Skylab 1 remained in orbit until July 11, 1979, when it re-entered Earth's atmosphere over the Indian Ocean and Western Australia after completing 34,181 orbits.[8]

The Apollo-Soyuz Test Project (ASTP) of July 1975, the final application of the Apollo Program, marked the first international rendezvous and docking in space, and was the first major cooperation between the only two nations engaged in manned space flight. As the first meeting of two manned spacecraft of different nations in space, first docking, and first visits by astronauts and cosmonauts into the others' spacecraft, the ASTP was highly significant. The ASTP established workable joint docking mechanisms, taking the first steps toward mutual rescue capability of both Russian and American manned missions in space.[9]

On January 5, 1972, President Nixon delivered a speech in which he outlined the end of the Apollo era and the future of a reusable space flight vehicle, the Space Shuttle, which would provide "routine access to space." By commencing work at this time, Nixon added, "we can have the Shuttle in manned flight by 1978, and operational a short time after that".[10] The Space Task Group (STG), previously established by President Nixon in February 1969 to recommend a future course for the U.S. Space Program, presented three choices of long-range space plans. All

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[6] National Aeronautics and Space Administration (NASA). *Facts: John F. Kennedy Space Center*. (1994), 82.
[7] NASA, *Facts*, 86-90.
[8] NASA, *Facts*, 91.
[9] NASA, *Facts*, 96.
[10] Marcus Lindroos. "President Nixon's 1972 Announcement on the Space Shuttle." (NASA Office of Policy and Plans, NASA History Office, updated April 14, 2000).

included an Earth–orbiting space station, a space shuttle, and a manned Mars expedition.[11] Although none of the original programs presented was eventually selected, NASA implemented a program, shaped by the politics and economic realities of its time, that served as a first step toward any future plans for implementing a space station.[12]

On January 5, 1972, President Richard Nixon instructed NASA to proceed with the design and building of a partially reusable space shuttle consisting of a reusable orbiter, three reusable main engines, two reusable solid rocket boosters (SRBs), and one non-reusable external liquid fuel tank (ET). NASA's administrators vowed that the shuttle would fly at least fifty times a year, making space travel economical and safe. NASA gave responsibility for developing the shuttle orbiter vehicle and overall management of the Space Shuttle Program (SSP) to the Manned Spacecraft Center (MSC; now Johnson Space Center [JSC]) in Houston, based on the Center's experience. MSFC in Huntsville, Alabama was responsible for development of the Space Shuttle Main Engine (SSME), SRBs, the ET, and for all propulsion-related tasks. Engineering design support continued at MSC, MSFC and NASA's Langley Research Center (LaRC), in Virginia, and engine tests were to be performed at NASA's Mississippi National Space Technology Laboratories (NSTL, later named Stennis Space Center [SSC]) and at the Air Force's Rocket Propulsion Laboratory in California, which later became the Santa Susana Field Laboratory (SSFL).[13] NASA selected KSC as the primary launch and landing site for the SSP. KSC, responsible for designing the launch and recovery facilities, was to develop methods for shuttle assembly, checkout, and launch operations.[14]

On September 17, 1976, the full-scale Orbiter Vehicle (OV) prototype *Enterprise* (OV- 101) was completed. Designed for test purposes only and never intended for space flight, structural assembly of this orbiter had started more than two years earlier in June 1974 at Air Force Plant (AFP) 42 in Palmdale, California. Although the *Enterprise* was an aluminum shell prototype incapable of space flight, it reflected the overall design of the orbiter. As such, it served successfully in 1977 as the test article during the Approach and Landing Tests (ALT) aimed at checking out both the mating with the Boeing 747 Shuttle Carrier Aircraft (SCA) for ferry operations, as well as the orbiter's unpowered landing capabilities.

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[11] National Aeronautics and Space Administration (NASA), History Office, NASA Headquarters. "Report of the Space Task Group, 1969."
[12] Dennis R. Jenkins. *Space Shuttle, The History of the National Space Transportation System. The First 100 Missions*. (Cape Canaveral, Florida: Specialty Press, 2001), 99.
[13] Jenkins, 122.
[14] Linda Neuman Ezell. *NASA Historical Databook Volume III Programs and Projects 1969-1978*. The NASA History Series, NASA SP-4012, (Washington, D.C.: NASA History Office, 1988), Table 2-57; Ray A. Williamson. "Developing the Space Shuttle." *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space*. (Edited by John M. Logsdon. Washington, D.C.: U.S. Printing Office, 1999), 172-174.

The first orbiter intended for space flight, *Columbia* (OV-102*)*, arrived at KSC from the shuttle assembly facility in Palmdale, California in March 1979. Originally scheduled to lift off in late 1979, the launch date was delayed by problems with both the SSME components as well as the thermal protection system (TPS). *Columbia* spent 610 days in the Orbiter Processing Facility (OPF), another thirty-five days in the Vehicle Assembly Building (VAB) and 105 days on Pad 39A before finally lifting off on April 12, 1981. STS-1, the first orbital test flight and first Space Shuttle Program mission, ended with a landing on April 14 at Edwards Air Force Base (AFB) in California. This launch demonstrated *Columbia's* ability to fly into orbit, conduct on-orbit operations, and return safely.[15] *Columbia* flew three additional test flights in 1981 and 1982, all with a crew of two. The Orbital Test Flight Program ended in July 1982 with 95 percent of its objectives completed. After the end of the fourth mission, President Ronald Reagan declared that with the next flight the Shuttle would be "fully operational."

A total of 122 Space Shuttle missions have been launched from the KSC between April 1981 and March 2008. From April 1981 until the *Challenger* accident in January 1986, between two and nine missions were flown yearly, with an average of four to five per year. The milestone year was 1985, when nine flights were successfully completed. The years between 1992 and 1997 were the most productive, with seven or eight yearly missions. Since 1995, in addition to its unique responsibility as the shuttle launch site, KSC also became the preferred landing site.

Over the past two decades, the SSP has launched a number of planetary and astronomy missions including the HST, the Galileo probe to Jupiter, Magellan to Venus, and the Upper Atmospheric Research Satellite. In addition to astronomy and military satellites, a series of Spacelab research missions were flown which carried dozens of international experiments in disciplines ranging from materials science to plant biology. Spacelab was a manned, reusable, microgravity laboratory flown into space in the rear of the Space Shuttle cargo bay. It was developed on a modular basis allowing assembly in a dozen arrangements depending on the specific mission requirements.[16] The first Spacelab mission, carried aboard *Columbia* (STS-9), began on November 28, 1983. Four Spacelab missions were flown between 1983 and 1985. Following a hiatus in the aftermath of the *Challenger* disaster, the next Spacelab mission was not launched until 1990. In total, 24 Space Shuttle missions carried Spacelab hardware before the program was decommissioned in 1998.[17] In addition to astronomical, atmospheric, microgravity, and life sciences missions, Spacelab was also used as a supply carrier to the HST and the Soviet space station *Mir*.

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[15] Jenkins, 268.
[16] National Aeronautics and Space Administration (NASA). *NASA Shuttle Reference Manual*. (1988).
[17] STS-90, which landed on May 3, 1998, was the final Spacelab mission. National Aeronautics and Space Administration (NASA). "Shuttle Payloads and Related Information." KSC Factoids. Revised November 18, 2002. Accessed at http://www-pao.ksc.nasa.gov/kscpao/factoids/relinfo1.htm.

In 1995, a joint U.S./Russian Shuttle-*Mir* Program was initiated as a precursor to construction of the International Space Station (ISS). *Mir* was launched in February 1986 and remained in orbit until March 2001.[18] The first approach and flyaround of *Mir* took place on February 3, 1995 (STS-63); the first *Mir* docking was in June 1995 (STS-71). During the three-year Shuttle-*Mir* Program (June 27, 1995 to June 2, 1998) the Space Shuttle docked with *Mir* nine times. All but the last two of these docking missions used the Orbiter *Atlantis*. In 1995, Dr. Norman Thagard was the first American to live aboard the Russian space station. Over the next three years, six more U.S. astronauts served tours on *Mir*. The Shuttle served as a means of transporting supplies, equipment and water to the space station in addition to performing a variety of other mission tasks, many of which involved earth science experiments. It returned to Earth experiment results and unneeded equipment. The Shuttle-*Mir* program served to acclimate the astronauts to living and working in space. Many of the activities carried out were types they would perform on the ISS.[19]

On December 4, 1999, *Endeavour* (STS-88) launched the first component of the ISS into orbit. As noted by Williamson, this event marked, "at long last the start of the Shuttle's use for which it was primarily designed – transport to and from a permanently inhabited orbital space station."[20] STS-96, launched on May 27, 1999, marked the first mission to dock with the ISS. Since that time, most Space Shuttle missions have supported the continued assembly of the space station. As currently planned, ISS assembly missions will continue through the life of the Space Shuttle Program.

The SSP suffered two major setbacks with the tragic losses of the *Challenger* and *Columbia* on January 28, 1986 and January 16, 2003, respectively. Following the *Challenger* accident, the SSP was suspended, and President Ronald Reagan formed a thirteen-member commission to identify the cause of the disaster. The Rogers Commission report, issued on June 6, 1986, which also included a review of the SSP, concluded "that the drive to declare the Shuttle operational had put enormous pressures on the system and stretched its resources to the limit".[21] In addition to mechanical failure, the Commission noted a number of NASA management failures that contributed to the catastrophe. As a result, among the tangible actions taken were extensive redesign of the SRBs; upgrading of the Space Shuttle tires, brakes, and nose wheel steering mechanisms; the addition of a drag chute to help reduce speed upon landing; the addition of a crew escape system; and the requirement for astronauts to wear pressurized flight safety suits during launch and landing operations. Other changes involved reorganization and

[18] Tony Reichhardt (editor). *Space Shuttle, The First 20 Years*. (Washington, D.C.: Smithsonian Institution, 2002), 85.
[19] Judy A. Rumerman, with Stephen J. Garber. *Chronology of Space Shuttle Flights 1981-2000*. HHR-70. (Washington, D.C.: NASA History Division, Office of Policy and Plans, October 2000), 3.
[20] Ray A. Williamson. "Developing the Space Shuttle." *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space*. Edited by John M. Logsdon. (Washington, D.C.: U.S. Printing Office, 1999), 191.
[21] Columbia Accident Investigation Board (CAIB). *Report Volume I*. (August 2003), 25.

decentralization of the SSP. NASA moved the management of the program from JSC to NASA Headquarters, with the aim of preventing communication deficiencies.[22] Experienced astronauts were placed in key NASA management positions, all documented waivers to existing flight safety criteria were revoked and forbidden, and a policy of open reviews was implemented.[23] In addition, NASA adopted a Space Shuttle flight schedule with a reduced average number of launches, and discontinued the long-term practice of launching commercial and military payloads.[24] The launch of *Discovery* (STS-26) from KSC Pad 39B on September 29, 1988 marked a Return to Flight after a thirty-two-month hiatus in manned spaceflight following the *Challenger* accident.

In the aftermath of the 2003 *Columbia* accident, a seven month investigation ensued, concluding with the findings of the Columbia Accident Investigation Board (CAIB), which determined that both technical and management conditions accounted for the loss of the orbiter and crew. According to the CAIB Report, the physical cause of the accident was a breach in the thermal protection system (TPS) on the leading edge of the left wing, caused by a piece of insulating foam, which separated from the ET after launch and struck the wing.[25] NASA spent more than two years researching and implementing safety improvements for the orbiters, SRBs and ET. Following a two-year hiatus, the launch of STS-114 on July 26, 2005 marked the first Return to Flight since the loss of *Columbia*.

On January 14, 2004, President George W. Bush outlined a new space exploration initiative in a speech given at NASA Headquarters.

> *Today I announce a new plan to explore space and extend a human presence across our solar system . . . Our first goal is to complete the International Space Station by 2010 . . . The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station. In 2010, the Space Shuttle – after nearly 30 years of duty – will be retired from service. . . Our second goal is to develop and test a new spacecraft, the Crew Exploration Vehicle, by 2008, and to conduct the first manned mission no later than 2014. . . Our third goal is to return to the Moon by 2020, as the launching point for missions beyond ...*[26]

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[22] CAIB, 101.
[23] Cliff Lethbridge. "History of the Space Shuttle Program." (2001), 4.
[24] Lethbridge, 5.
[25] CAIB, 9.
[26] The White House. "A Renewed Spirit of Discovery – The President's Vision for Space Exploration." (January 2004).

Following the President's speech, NASA released *The Vision for Space Exploration*, which outlined the Agency's approach to the new direction in space exploration.[27] In 2006, NASA announced the start of the Constellation Program, which included development of the Crew Exploration Vehicle (CEV) and a launch vehicle to place the CEV into space. As part of this initiative, NASA will continue to use the Space Shuttle to complete assembly of the ISS. The Shuttle will not be upgraded to serve beyond 2010 and, after completing the ISS, the Space Shuttle Program will be retired. The next generation of human-rated spacecraft, the CEV, named *Orion*, will transport humans to low Earth orbit for missions to support the ISS, and will also be the vehicle used to carry a crew to lunar orbit. The Constellation Program will develop the new class of exploration vehicles to launch both crew and cargo and associated infrastructure in exploring the Moon, Mars, and beyond.

Development of KSC's LC 39 and VAB Areas

Today, KSC maintains operational control over 3,800 acres, all located in Brevard County. The major facilities are located within the Industrial Area, the LC 39 Area, the VAB Area, and the Shuttle Landing Facility (SLF) Area. The LC 39 and VAB Areas were developed primarily to support launch vehicle operations and related launch processing activities. They contain the VAB, the Launch Control Center (LCC), the Orbiter Processing Facilities (OPF), the two Launch Pads, A and B, and other support facilities.

Following completion of the Apollo-Soyuz Test Project in 1975, the facilities of KSC were modified to support the Space Shuttle Program. KSC was originally one of three possible launch sites evaluated, along with Vandenberg AFB in California and the White Sands Missile Range in New Mexico. Compared with the other two locations, KSC had the advantage of approximately $1 billion in existing launch facilities. Thus, less time and money would be needed to modify existing facilities at KSC rather than to build new ones at another location. The estimates of $200 to $400 million to modify the existing KSC facilities was roughly half the cost of new construction. In addition, only KSC had abort options for a first revolution return of the low cross-range orbiter.[28]

To help keep costs down, beginning ca. 1976, KSC engineers adapted and modified many of the Apollo launch facilities to serve the needs of the SSP. Among the key facilities undergoing change were the VAB, the LCC, and LC 39 Pads A and B. New facilities were constructed only when a unique requirement existed. The major new structures included the SLF and the OPFs. Multi-million dollar contracts for design and construction were awarded to both national and local firms, including Reynolds, Smith and Hills (RS&H) of Jacksonville, Florida; the Frank

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[27] National Aeronautics and Space Administration (NASA), Headquarters. "The Vision for Space Exploration." (February 2004).
[28] Jenkins, 112.

Briscoe Company, Inc. of East Orange, New Jersey; the Algernon Blair Industrial Contractors, Inc. of Norcross, Georgia; the Holloway Corporation of Titusville, Florida; and W&J Construction Corporation of Cocoa, Florida.

Alterations to the VAB included modification of two of the four high bays for assembly of the Space Shuttle vehicle, and changes to the other two high bays to accommodate the processing and stacking of the SRBs and ET. The north doors were widened by almost 40' to permit entry of the towed orbiter. Work platforms shaped to fit the shuttle configuration were added to High Bay 3 where shuttle assembly takes place, and internal structural changes were also made to High Bay 4, where the ETs are processed.

Major changes were made to LC 39, Pads A and B. Modifications were completed in mid-1978 at Pad A and in 1985 at Pad B. With the exception of the six fixed pedestals which support the Mobile Launcher Platform (MLP), all of the structures on the hardstands of each pad were removed or relocated. Fuel, oxidizer, high-pressure gas, electrical, and other service lines were rerouted. New hypergolic fuel and oxidizer support areas were constructed at the southwest and southeast corners, respectively, of the pads; the unneeded Saturn fuel support area was removed, a new Fixed Service Structure (FSS) was erected using the original Apollo-era Launch Umbilical Tower (LUT), a Rotating Service Structure (RSS) was added, the Saturn flame deflectors were replaced, and a Payload Changeout Room (PCR) and Payload Ground Handling Mechanism (PGHM) were added. A sound suppression water system was installed on the pads to reduce the acoustical levels within the orbiter's payload and thus, to protect it and its payloads from damage. A related system, the Overpressure Suppression System, was installed to reduce the pressure pulse at SRB ignition.

Additional changes were made to Pad A and Pad B in the aftermath of the 1986 *Challenger* accident; other modifications followed the Return to Flight in 1988. Among the modifications were the installation of new weather protection structures to supplement the RSS; improvements in temperature and humidity controls at the PCR of the RSS; upgrades to the emergency exit system, including the addition of two slidewire baskets; installation of new elevators on the RSS; and improvements to the pad communications system. Changes were first made at Pad B, followed by identical changes at Pad A.

The Launch Control Center

The Launch Control Center (LCC), the "brain" of LC 39, was built originally to provide launch control in support of the Apollo, Skylab, and the Apollo-Soyuz programs. It currently supports prelaunch and launch operations for the Space Shuttle Program. The LCC was designed by a consortium of four New York architectural and engineering firms, organized in 1962 as URSAM after the first letter in each of the company's names (Max Urbahn [architectural]; Roberts and

Schaefer [structural]; Seelye, Stevenson, Value and Knecht [civil, mechanical and electrical]; and Moran, Proctor, Mueser and Rutledge [foundations], New York. URSAM, which also designed the VAB, was awarded a $5.49 million contract on December 4, 1962 to design the LCC as well as the VAB and adjacent permanent facilities.[29]

The "ground rules" for the design of the LCC building were established by the Manned Space Flight Management Council in June 1962.[30] Although the original plans specified a steel structure, the final choice was a reinforced-concrete building, in accordance with the recommendation of the structural engineers, who viewed concrete as better for acoustical purposes. URSAM architect Martin Stein began the design of the LCC in January 1963 (Covington 1969). He wanted the building to be "expressive of man's future," and to be "man's window to see the world which was to be."[31] Because the requirements for equipment inside the firing rooms were unknown at the time, Stein's design concept emphasized flexibility.

> *The Firing Rooms were to be as open as possible with no columns and as flexible as possible for the equipment. The large windows were provided so that people could see what was going on at the launch pad. The two firing rooms serve as one building next to the other two firing rooms or two buildings separated by a two inch gap.*[32]

Double-paned windows with special heat- and shock-resistant glass extended the full width of the rear of the firing room, facing the launch area. They were designed "to shut off the sounds and pressures of the outside world;" infrared lamps outside the windows prevented fogging.[33] On the outside, large vertical louvers "could be closed in a few moments for further protection."[34] URSAM won the 1965 Architectural Award for industrial design of the year for its work at the LCC.[35]

LOC engineers determined how the LCC would be equipped, and in late 1963 the conceptual design and organization of the firing rooms was addressed.

> *Nearly 450 consoles would be operated by representatives from the stage contractors and Radio Corporation of America, General Electric, Saunders,*

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[29] Charles D. Benson and William Barnaby Faherty. *Moonport: A History of Apollo Launch Facilities and Operations.* (Washington, D.C.: NASA History Office, NASA Special Publication – 4204, 1978); Benson and Faherty, *Gateway to the Moon*, 225.
[30] Benson and Faherty, 203.
[31] James Covington. Interview with Martin Stein, Project Architect for the LCC. (August 8, 1969. Interview notes on file, KSC Archives, Kennedy Space Center, Florida).
[32] Covington.
[33] Benson and Faherty, *Moonport*; Covington.
[34] Benson and Faherty, *Gateway to the Moon,* 261.
[35] Benson and Faherty, *Gateway to the Moon,* 231.

> *Symetrics, International Telephone and telegraph, NASA, and the Eastern Test Range. The consoles were arranged to permit the Boeing, North American, and other teams of engineers to sit together in their respective stage groupings. Responsibility for designing the consoles rested primarily with the various companies, but the designs were coordinated by LOC.*[36]

On January 16, 1964, a $63.36 million contract for general construction and outfitting of the LCC (and other facilities in the VAB area) was awarded to three South Gate, California construction-engineering firms: Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman, Inc. The LCC was structurally completed in 1965. The first floor originally contained offices, a dispensary and a cafeteria, while the second floor was allocated to telemetry, measuring and checkout systems for use during vehicle assembly and launch operations. Four firing rooms, one for each high bay in the VAB, occupied the third floor, and the fourth floor had conference rooms and displays.[37] The original plan called for four firing rooms of which one was never to be equipped.[38] Nearly 100 miles of cable were required for communication and instrumentation from the LCC to Pad B alone.[39]

No structural changes were made to the LCC in preparation for the SSP operations, including alterations to the exterior or interior configuration. However, prior to 1974, development of a new Space Shuttle Launch Processing System (LPS) was underway at KSC. The new single automated computer system was designed to replace the multiple systems used in previous programs. The LPS would provide a means of "performing systems testing, launch operations control and status monitoring of the vehicle, ground support equipment and facilities during ground operations."[40] It has sister systems in the Orbiter Processing Facility (OPF), the VAB and its utility annex, and the Hypergolic Maintenance Facility to monitor vehicle and component processing, checkout, and mating procedures; sister systems on the MLPs and at the two launch complexes control fueling and launching procedures. There is also a sister system in the Landing Aids Control Building to monitor landing procedures. The LPS reduced the processing time between flights, and allowed two vehicles to be processed simultaneously.

The LPS consists of three major subsystems: the Checkout, Control and Monitor Subsystem (CCMS); the Central Data Subsystem (CDS); and the Record and Playback Subsystem (RPS). The CCMS includes the operator-manned consoles in the firing rooms; all consoles work together on major tasks through an Integration Console at the front of the firing room. The CDS, upgraded in 1999 to a cluster of high-end minicomputers now called the Shuttle Data Center

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[36] Benson and Faherty, *Moonport*; Benson and Faherty, *Gateway to the Moon,* 233.
[37] Benson and Faherty, *Gateway to the Moon,* 260.
[38] Benson and Faherty, *Gateway to the Moon,* 261.
[39] Kay Grinter. "40 years ago: Firing Room 1 was crucial to launch site activation." *Spaceport News* (45, 20), 13 October 2006: 7
[40] "Launch Processing System Being Developed For Space Shuttle." *Spaceport News* (13, 2), 24 January 1974: 4.

(SDC), is located on the second floor of the LCC. The primary function of the RPS is to record unprocessed Shuttle instrumentation data during tests and launch countdowns, which can then be played back for post-test analysis.

In December 1975, LPS installation was begun in two firing rooms by the Holloway Corporation of Titusville. In January and February 1978, installation of the Checkout, Control and Monitor Subsystem of the LPS was completed in Firing Room Nos. 1 and 2 (FR-1 and FR-2); similar work in Firing Room No. 3 (FR-3) was completed in January 1982. In March 1983, Behe and Umholtz Electrical Contractors of Orlando was awarded a $1.27 million contract to convert Firing Room 4 (FR-4) into additional office space and a conference room.

Mostly because of the LPS, fewer personnel are required in the firing room to check out and launch the Space Shuttle compared with Apollo manned missions. Also, the new LPS helped reduce the Shuttle's final countdown from the twenty-eight hours required for Apollo to only three hours.[41] With the new LPS, the consoles were turned around so that engineers monitoring the launch could look out the window "instead of at the back wall as they had all through the Apollo years."[42] "Approximately 500 people support a typical launch countdown with about 180 engineers in the primary firing room."[43] Additional team members are in the backup firing rooms, the MILA tracking station, at CCAFS, and in Houston. A team of approximately twenty NASA Test Directors staff the firing rooms "24 hours a day, seven days a week conducting all the tests necessary to prepare the vehicles for launch."[44]

Recalling the advancements brought to the Shuttle's first launch on April 12, 1981 by the new LPS, John T. Fowler, director of Information Systems, noted:

> *The big challenge was that this was the first time KSC was entrusted by NASA with the entire responsibility for the development of a critical launch checkout system. Previously, in the Apollo and Skylab programs, much of the checkout equipment was heritage Marshall and JSC. The first Shuttle launch attempt required us to operate all of the firing room consoles continuously for a period of almost 48 hours without any of them going down. And for the first time ever – none went down* (*Spaceport News* 27 October, 2000:3).

Between June and August 1992, a $300,000 project to replace the cracked and damaged 27-year old original windows in the LCC was initiated. The Brevard Plate Glass Company was awarded

[41] Anna Heiney. "Kennedy readies facilities for shuttle in less than a decade." *Spaceport News* (45, 8), 14 April 2006:5; National Aeronautics and Space Administration (NASA), Kennedy Space Center (KSC). *Countdown! NASA Launch Vehicles and Facilities*. Information Summaries PMS 018-A (KSC), July 1989:16.
[42] Kenneth Lipartito and Orville R. Butler. *A History of the Kennedy Space Center*. (Gainesville: University Press of Florida, 2007), 224.
[43] "Launch team leaders manage Space Shuttle's vital signs." *Spaceport News* (30, 17), 30 August 1991:6.
[44] "Launch team leaders," 6.

the contract, which entailed removing the 370 original windowpanes and installing new neoprene gaskets. The new three-quarter-inch, 5' x 4' windows are composed of three plies of clear one-quarter-inch laminated glass panes, and contain layers of tinted, laminated material.[45] Window replacement had originally been scheduled for between 1993 and 1995, but was accelerated by KSC Director Bob Crippen.

As operating in 1993 for the SSP, FR-1 and FR-3 were configured for full control of launch and orbiter operations, while FR-2 was usually used for software development and testing. FR-4, only a partial firing room, was used primarily as an engineering analysis and support area for launch and checkout operations.

In 1996, NASA initiated the Checkout and Launch Control System (CLCS) project, a large and complex computer upgrade to control space shuttle processing and launches. This initiative proposed major improvements over the LPS, including the capability to monitor more than one orbiter from the same firing room. Three control rooms were proposed for redesign. Prototype consoles for the CLCS were set up in an experimental control room located in FR-2.[46] The project was scheduled for completion and full operation by September 2001. However, in 2002, after five years of work and almost $300 million spent, NASA cancelled this proposed successor to the LPS because of missed deadlines and cost overruns.[47]

At the time of documentation (May 2008), FR-2, FR-3, and FR-4 were in active use for the Space Shuttle Program. In 2004, KSC began a major renovation of FR-4, which "gave designers an opportunity to blast away from the past and build the ideal space shuttle launch control room."[48] What was originally divided into office space, a conference room, and a small firing room, was opened into one large space resembling the other three firing rooms.[49] Upgrades included sound-suppressing walls and floors, new humidity control, fire-suppression systems and consoles, support tables with computer stations, communication systems and laptop computer ports, as well as power and computer network connections and a newly improved Checkout, Control and Monitor Subsystem.[50] After two years of work, renovations to FR-4 were completed in 2006. FR-4 debuted on July 4, 2006 for the launch of STS-121, and has since been the prime

[45] Jon Ewing. "Launch Control Center gets new windows." *Spaceport News* (31, 14), 17 July 1992:5.
[46] "KSC begins work on LPS successor." *Spaceport News* (36, 6), 28 March 1997:1.
[47] John Kelly. "NASA Kills 'Wounded' Launch System Upgrade at KSC." *Florida Today* 18 September 2002; National Aeronautics and Space Administration (NASA), Kennedy Space Center (KSC). "New Checkout and Launch Control System Under Development at Kennedy Space Center." NASA News Release on Line, John F. Kennedy Space Center, March 27, 1997, KSC Release No. 53-97; "CLCS team faces challenge, shows solidarity." *Spaceport News* (41, 20) 4 October 2002: 1 and 6.
[48] Charlie Plain. "Firing Room 4 debuts for STS-121." *Spaceport News* (45, 13), 7 July 2006:3.
[49] Plain, 3.
[50] Jennifer Wolfinger. "Upgrades enhance LCC firing room equipment." *Spaceport News* (43, 18), 27 August 2004:5.

firing room used for every launch. It is also designated as the primary firing room for all remaining shuttle launches.[51]

As the brains of the shuttle operations, there are always activities occurring in the three firing rooms. With three active orbiters, each firing room is generally responsible for one of the orbiters. FR-4 typically monitors the vehicle that is first in line to be launched, and continues observation until that orbiter has landed at KSC and has been moved to its designated OPF.[52] This includes observing the stacking and testing procedures in the VAB, and additional testing and payload operations at the launch pad. FR-3 usually manages the orbiter that is second in line for launch, which typically involves the testing and processing protocol that occurs in the OPF, and the stacking and testing procedures within the VAB. In addition, FR-3 serves as the back-up to FR-4, and thus can monitor the testing and payload operations at the launch pad. FR-2 monitors the vehicle that is third in line for launch, which generally includes the orbiter testing and processing done within the OPF, and may include stacking and testing operations in the VAB. Control over the orbiters does not switch between the firing rooms until the vehicle in orbit has been returned to its OPF. At that point, FR-4 takes over the orbiter previously under the direction of FR-3; FR-3 receives control of the orbiter previously in FR-2; and FR-2 secures control over the orbiter which has just completed its mission.[53]

Historically, FR-1 of the LCC was set up with software used to simulate flight and ground systems in the launch configuration, and was used by Shuttle launch team members for training, including tests and simulations to prepare for worse-case scenarios.[54] In 2006, NASA began to renovate FR-1 for the new Constellation Program. It is the first SSP facility at KSC to be transferred to the Constellation Program for reuse, and will control the first test flight of an Ares I rocket in April 2009.[55] Prior to this launch, the new equipment will be used by members of the launch team to practice. As part of the renovation project, all equipment above the raised floor was removed, including the consoles, console enclosures, furniture, electronic equipment, racks, plaques and on-station manuals. Much of the electronics in the consoles were salvaged for spares. The remaining materials were moved to KSC's disposal facility where they are stored awaiting final disposition. In April 2006, FR-1, which launched STS-1, was renamed the "Young-Crippen Firing Room" to honor Commander John Young and Pilot Robert Crippen, and to pay tribute to the twenty-fifth anniversary of the first space shuttle flight on April 12, 1981.[56]

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[51] Westly Mosedale. Interview with Patricia Slovinac, KSC, Launch Control Center, 16 May 2008.
[52] Should the orbiter land at Edwards Air Force Base in California, FR-4 remains in control until the orbiter is ferried back to KSC, and has reached its designated OPF.
[53] Mosedale.
[54] "Launch simulation keeps team sharp." *Spaceport News* (44, 6), 18 March 2005:7.
[55] Linda Herridge. "Historic Firing Room 1 to be remodeled for transfer to the Constellation Program." *Spaceport News* (45, 20), 13 October 2006:5; Steven Siceloff. "Changes planned in progress for Kennedy's future in Constellation Program." *Spaceport News* (47, 21) 5 October 2007: 4.
[56] Linda Herridge. "KSC dedicates Young-Crippen Firing Room." *Spaceport News* (45, 9), 28 April 2006:3. Historically, before the Space Shuttle Program, Firing Room 1 was the "most popular" control room during the

A call to stations from the LCC firing room initiates the countdown sequence. This verifies that all required personnel are ready to support the countdown activities.[57] A typical Space Shuttle launch countdown begins approximately seventy-two hours prior to launch, at T-43 hours and counting.[58] For the next sixteen hours, final checkouts are conducted, software is loaded, and the middeck and flight deck platforms are removed. Around T-28 hours, preparations begin for loading the orbiter's fuel cell power reaction and storage distribution systems. At T-27 hours and holding, a four-hour hold commences while the launch pad is cleared of all non-essential personnel. When the countdown begins again, the cryogenic reactants are loaded into the orbiter's fuel cell storage tanks. Another hold begins at T-19 hours and holding, when the orbiter's midbody umbilical unit is demated, which usually lasts about four hours. When the countdown begins again, at T-19 hours and counting, final preparations are made for loading the fuel for the main engines, filling the water tank for the sound suppression system, and closing out the tail service masts on the MLP.

At T-11 hours and holding, the rotating service structure is removed and the orbiter's communications systems are activated. This hold sequence typically lasts twelve to thirteen hours. Once countdown resumes, the orbiter's fuel cells are activated, and non-essential personnel are cleared from the blast area. At T-6 hours and holding, typically a two-hour hold, the launch team verifies that there are no violations of the launch commit criteria, and all personnel are cleared from the launch pad. In addition, fueling procedures for the external tank begin, and continue through the T-6 and counting stage. At T-3 hours and holding, the final inspection team proceeds to the launch pad for a detailed analysis of the Space Shuttle vehicle, and the closeout crew begins to configure the crew module for countdown and launch. After this two hour hold, at T-3 and counting, the astronauts arrive at the launch pad and begin their entry into the orbiter. Additional air-to-ground voice checks are conducted between the LCC and Mission Control Center (MCC) at the JSC in Houston. The orbiter crew hatch is closed and checked for leaks before the closeout crew retreats to the fallback area.

Beginning at T-20 minutes and holding, the Shuttle Test Director conducts the final briefings for the launch team and preflight alignments of the inertial measurement unit are completed. After this ten-minute hold, the countdown begins again at T-20 minutes and counting. During this period, the orbiter's onboard computers and backup flight system are switched to launch configuration, and the thermal conditioning for the fuel cells are begun. The final built-in hold

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Apollo era, and is associated with the first Saturn V (Apollo 4) unmanned launch on November 4, 1967; the first lunar orbital mission (Apollo 8) on December 21, 1968; and the first lunar landing mission (Apollo 11) on July 16, 1969

[57] National Aeronautics and Space Administration (NASA), *NASA Shuttle Reference Manual*. 1988.

[58] The discrepancy between the official designation of T-43 hours and the reality that the clock is started roughly seventy-two hours prior to launch, is due to built in hold periods throughout the sequence, in which certain actions actions are performed, and conditions and processes are verified. These holds can last from as little as ten minutes to as long as thirteen hours, assuming there are no unanticipated delays.

occurs at T-9 minutes and counting, when the Launch Director, the Shuttle Test Director and the Mission Management Team confirm a go/no go for launch. This hold varies in length depending on the mission. Final countdown begins at T-9 minutes and counting. At this time, the automatic ground launch sequencer is started, and final tests and preparations for launch are completed. Once the SRBs ignite at liftoff, or T-0, mission responsibility is transferred to the MCC at the JSC.

The LCC was listed in the National Register of Historic Places on January 21, 2000. It was nominated under cover of the Multiple Property Listing, *Historic Cultural Resources of the John F. Kennedy Space Center, Florida* for its exceptional national importance within the context of the Apollo Space Program, 1961 through 1975. The original Multiple Property submission was prepared between 1997 and 1998, and signed by the Florida State Historic Preservation Officer in August 1998. The Multiple Property Documentation Form and LCC nomination were revised in 2007 to include the Space Shuttle Context, ca. 1969 – 2010.[59] The LCC is eligible under Criterion A in the areas of Space Exploration and Communication and under Criterion C in the area of Architecture. Because it has achieved exceptional significance within the past 50 years, Criteria Consideration G applies.

[59] Trish Slovinac and Joan Deming. National Register of Historic Places Multiple Property Documentation Form, *Historic Cultural Resources of the John F. Kennedy Space Center, Florida.* October 2007

Physical Description

Exterior

The Launch Control Center (LCC), which was designed following the principles of the International Style, is a four-story, rectangular structure that measures approximately 378' in length, 182' in width, and 76' in height. It sits towards the southeast of the VAB, and is oriented so that it lies nearly perpendicular to the two Launch Complexes (39A and 39B), with each corner of the building pointing along one of the cardinal directions.[60] It is constructed of reinforced concrete (precast and prestressed), sits on a poured concrete slab foundation, and has a flat, reinforced concrete roof topped by a layer of asphalt.[61] An enclosed bridge at the third floor level provides direct access to the VAB.

Although the south elevation of the LCC is used as the main access point of the facility, the north elevation, which faces the Crawlerway and the two Launch Pads, is the principal façade (Photos 1 and 2). In general, the elevation is divided into two horizontal halves. The lower half contains the first two floor levels. The first floor is recessed approximately 11' and has a screen of pillars that continue through the second floor as pilasters. These pilasters divide the wall surface into fourteen vertical bays, each of which is faced with corrugated aluminum siding. Near the center of the façade, on the first floor, there are two pairs of metal swing doors. About halfway towards the east and west ends from the centerline there is another pair of metal swing doors, and at the east end is a fifth pair of metal swing doors. The second floor is void of openings. The upper half of the north elevation corresponds to the third and fourth floors, and is divided into five vertical bays. The central bay is the widest, comprising six of the fourteen second floor bays (Photos 2 and 57). To each side is a smaller bay, which is the same width as one of the second floor bays. The two end bays are each half the size of the central bay, comprising three second floor bays (Photos 6 and 57).

The central and end bays of the upper half of the north elevation correspond to the four internal firing rooms: two in the center and one at each end. In cross-section, these projections take a triangular form (Photos 6 and 60). Beginning at 31' above grade, the projection extends outwards for 6'-7" at an angle of 4.34 degrees from horizontal. From there, the surface angle changes to approximately 42 degrees from horizontal, and it projects to a point at 18'-10" from the second floor wall surface. From here, the upper face of the projection angles back to the roof at an angle

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[60] Covington. For ease of discussion, the elevation which faces northeast will be referred to as the north elevation, like the architectural plans. National Aeronautics and Space Administration, Shuttle Projects Office, Kennedy Space Center. "Space Shuttle Support Equipment/Facility (SE/FAC) Plan – Launch Control Center (LCC)." (January 1979. Engineering Documentation Center, Kennedy Space Center); Planning Research Corporation, Cape Canaveral. "Launch Complex 39, LCC, Space and Weight Allocation." (August 1977. Engineering Documentation Center, Kennedy Space Center); Urbahn Roberts Seelye Moran, New York. "LC 39 Vertical Assembly Building-LCC." (October 1963. Engineering Documentation Center, Kennedy Space Center).

[61] Benson and Faherty, *Gateway to the Moon,* 231.

of approximately 26 degrees from vertical. Within the upper surface of the projection are ribbons of five-light fixed windows: the end bays with sixteen and the central bay with thirty-two (or sixteen per firing room). The windows are 20'-8" in overall height, and each pane is 4' x 5' and composed of three layers of laminated glass.

To the outside of the windows is a 4'-deep pocket that contains vertical sun louvers, each of which measure 5' wide x 29' high (Photos 60 and 61). The louvers are composed of aluminum supports and shells, with urethane foaming plastic filling the hollow areas. These mechanically operated louvers pivot at their center, which lines up with the vertical window mullions. They are connected to each other, in groups of five, by metal rods at the top, which physically rotate the louvers from a fully closed position at 0-degrees, clockwise through the fully open position at 90-degrees, to a maximum angle of 150-degrees (Photos 21-24 and 62). Each firing room has three sets of five louvers (a total of fifteen), which can be operated all together or as separate sets from a control panel within the room; the actual motors are located within the base of the louver pocket (Photo 60).

The two aforementioned smaller bays correspond to the visitors galleries on the third floor, and office/meeting rooms on the fourth floor (Photo 2). These smaller bays have the same cross section as the firing rooms, but only extend for a total of 12' from the second floor wall surface, as opposed to the 18' of the firing rooms. These bays contain a ribbon of five-light fixed windows, exactly like those used in the firing rooms. Unlike the firing rooms however, these windows are not fitted with vertical louvers.

Supporting the third and fourth floor window from the inside are vertical aluminum bowstring trusses, defined by a straight bottom chord and arced top chord (Photo 46). Each truss is 20'-8" in length, the same as the height of the window, and has a maximum depth of 1'-0" at the centerline. There are four vertical support webs to the truss, one at each of the horizontal window mullions (except at the top and bottom, where the heels of the truss are located). Between the four vertical support webs are two diagonal webs that extend from the top chord to the midpoint of the bottom chord, creating an inverted "V".

Similar to the north elevation, the first floor of the south elevation is recessed behind a screen of pillars; however, the second and third floors project approximately 9' from the pillars, corresponding to a cable room and the access bridge, respectively (Photo 4). The main entrance to the LCC sits at the center of the façade and is comprised of two sets of double pairs of metal swing doors. To the east are two additional pairs of metal swing doors, which lead to the building's cafeteria. The second floor on this elevation is void of openings; the third floor has fourteen narrow, one-light fixed windows, which are spaced evenly across the facade. The central portion of the fourth floor, which contains the relief air louvers, sits roughly 30' back from the perimeter of the third floor; the last 53' on both the east and west ends is recessed approximately 57', creating a U-shaped terrace when viewed from above. At each end of the central section is a staircase to the upper roof level; and towards the inner side of each end portion is a pair of metal swing doors for access to the fourth floor.

Like the north and south elevations, the first floor of the east elevation is recessed behind a screen of pillars (Photo 5). Near the center of the façade is an external concrete stairwell, which extends to the fourth floor terrace. To the south of the first floor are two pairs of metal swing doors, providing access to the cafeteria area. The remainder of this floor is void of openings; the sole openings on the upper three levels are a metal swing door at each floor, which provides access to the concrete stairwell. There is also a door at the south end of the second floor level, which provides access to the cable trays that run through a room to the inside of the south wall. The west elevation is essentially a mirror of the east elevation, with one minor exception (Photo 3). At the first floor level, there is a pair of metal swing doors towards the north and south ends.

Interior

The first floor of the LCC contains the Operational Intercommunication System/Operational Television System (OIS/OTV) Control and Switching Area and the Complex Control Center (CCC), including the Fire/Safety/Security Control Center. The OIS/OTV Control Area, which sits at the northwestern corner, measures roughly 66' x 62' and contains the equipment consoles for the intercom and TV systems. The CCC is located along the southern wall, just west of the facility's centerline. This area measures approximately 73' x 55' and serves as the operating center from which direct support systems and equipment are monitored and controlled during shuttle landing, maintenance and checkout, vehicle integration, and launch. To its immediate north, the 29' x 27' Fire/Safety/Security Control Center coordinates and monitors the fire, safety and security activities within the LCC. The first floor also contains a cafeteria area (which extends through most of the eastern half of the floor), as well as various other general support areas.

The second floor of the LCC contains the Central Data Subsystem (CDS) Area, the Record and Playback Subsystem (RPS) Area, the Environment and Special Measurement System (ESMS) Area, and the Timing/Countdown Control Area. The two-room CDS Area extends across most of the second floor, with both the western and eastern rooms measuring approximately 134' in length and 56.5' in width. These rooms contain two large computers and various data storage devices, peripherals, and recording and transmission equipment required for sending digital data to KSC computer terminals and other NASA centers. The RPS Area sits at the southwest corner of the second floor. It measures roughly 68.5' x 44' and contains equipment for the recording and playback of all operational instrumentation and development flight instrumentation data. The ESMS Area, which sits at the northwest corner of the second floor and measures approximately 83' x 44', includes the equipment necessary for monitoring the KSC Lightning Warning System. The Timing/Countdown Control Area sits to the east of the ESMS area and measures roughly

30.5' x 26'. In this room is the equipment used to generate, control and distribute the timing and countdown signals for Launch Complex 39.

The third floor contains the four firing rooms, numbered FR-1 through FR-4, from west to east (Photos 53 and 54). At the time of documentation, FR-2 and FR-3 were the only firing room which maintained their historic configuration for the shuttle program, including the original layout, consoles and room finishes; FR-3 also still had the capability of launching the Space Shuttle. FR-3 measures approximately 145' in length and 80' in width, excluding the data room to the south. The west and east walls are painted gypsum wallboard, and the south wall is composed of acoustical panels. The north wall is comprised of a ribbon of windows, with mechanical louvers to the outside (described above). The floor is suspended 1'-6" above the concrete floor slab, and consists of 2' x 2' removable tiles, allowing space for the computer cabling to be run. The room also has exposed concrete ceilings, with surface mounted light fixtures. Also suspended from the ceiling is the fire suppression system, denoted by red-painted pipes. In addition, towards the west end of the south wall, is the control panel for the Halon emergency system (Photo 28).

FR-3 is spatially divided into two distinct areas. The northern area of the room is a 34' high space with a series of three stepped platforms, and a triangular-shaped, soundproofed room in each corner (Photo 15). On the upper platform, next to the windows, are the consoles for the Public Affairs Officer, the weather monitor, and the Launch Director. The middle platform includes the stations for the Orbiter Test Director, the NASA Test Director, and the Support Test Manager. The lowest platform has stations for the Safety Console Coordinator, the Payload Test Conductor and the Booster Test Conductor. The enclosed room within the northwest corner serves as the Operations Support Room (OSR; Photo 16), which contains the Mission Management Team, who give the final "go" for launch; the room in the northeastern corner serves as the Operations Management Room (OMR; Photo 18), which includes high-level personnel not directly involved with the launch, but serve primary roles in the shuttle program.

The remainder of FR-3, an area of approximately 104' in length and 80' in width, sits on a level surface and has a ceiling height of roughly 13' (Photos 9-11). It is arranged so that there are three arced consoles, with their wiring panels immediately to the south. The C-1 console, at the west, controls the payload operations; the HSP-2 (Hot Spare Panel) console in the center is a spare console-for use in case a main console fails to operate properly; and the C-2 console, at the east, monitors the navigation aids, communications equipment, the mechanical systems on the orbiter, and the payload electrical systems. Behind these three consoles are three additional pairs of arced consoles, again with their wiring panels immediately to the south. The first row contains the C-3 and C-4, which monitor the orbiter's cryogenics and main propulsions systems, to the west and the C-5 and C-6 consoles, which control the Range Safety System, the Environmental Control and Life Support System, the Environmental Control Systems, and the Power Reactant and Storage Distribution System, to the east. Within the second row, to the west, are the C-7 and C-8 consoles, responsible for the swingarms on the launch pad, the hypergolic fuels, monitoring the hypergolic pressure, and controlling the auxiliary power units and the hydraulic power units. To the east of the second row are the C-9 and C-10 consoles, which monitor hazardous gas levels, as well as the orbiter's instrumentation and electrical power systems. The last row contains the C-11 and C-12 consoles, that monitor the orbiter's avionics systems, to the west, and additional spare consoles to the east.

To the south of FR-3 is a computer/data collection area, which measures approximately 80' in length and 19' in width (Photo 30). Like the firing room, it contains painted gypsum board walls, an exposed ceiling with surface mounted light fixtures, and a raised, 2'x2' tile floor. This area has data collection equipment around the perimeter of the eastern half of the room, and two sets of consoles to the west.

At the time of documentation, FR-4 (Photos 40-43) served as the primary firing room for the shuttle program, following a complete refurbishment between 2004 and 2006. During this process, the west, south, and east walls were refinished, and the HVAC ducts were placed within a cove along their perimeter. The floor received wall-to-wall carpeting, and a drop-ceiling was added, and recessed light fixtures replaced the original surface-mounted fixtures. The lower console layout was altered to contain four pairs of consoles, which were also changed to sport wood veneer finishes. The consoles in the front area were also changed to wood veneer finishes, although their layout remained the same (Photo 40). In addition, the original sound-proofed OSR and OMR rooms were removed and new ones constructed, with gypsum board forming the lower part of the wall and glass panels above, which were extended to the ceiling (Photo 41). An elevator was also inserted to provide access to the OSR. In addition, the video monitors were removed from the upper wall surface to the south, and the countdown clock was replaced.

FR-2 (Photos 31-34) was also in its historic shuttle program arrangement; it was never fully equipped to serve as a launch control room. Its differences from FR-3 are minor, and consist of a full-width set of consoles at the front of the room on the main level and two different video screens at the sides of the front roof drop. In addition, the northwest corner room was converted into office space with the addition of removable partitions. FR-1, designated the Young/Crippen Firing Room in 2006, (Photo 48) was in the process of being retrofitted for the Constellation Program and no longer contained any historic interior fabrics or consoles. It will resemble FR-4 once finished.

Between Firing Room Nos. 1 and 2, and Firing Rooms Nos. 3 and 4 is a Visitor's Gallery on a mezzanine level, which is accessed by a small set of steps (Photo 49). These galleries have carpeted floors, painted gypsum board walls, and coffered ceilings. Above the western gallery, on the fourth floor, is a small conference room, also with carpeted floors, painted gypsum board walls, and a drop ceiling of 2'x 4' acoustic tiles (Photo 50). Above the eastern gallery is an office area for senior management, with the same room finishes. The remainder of the fourth floor contains office areas, display equipment rooms, and the mechanical equipment room.

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Photo A-1. Aerial of Kennedy Space Center, Launch Complex 39, January 16, 1976.
Launch Control Center denoted by arrow.
Source: John F. Kennedy Space Center Archives, 376C-11 FR03.

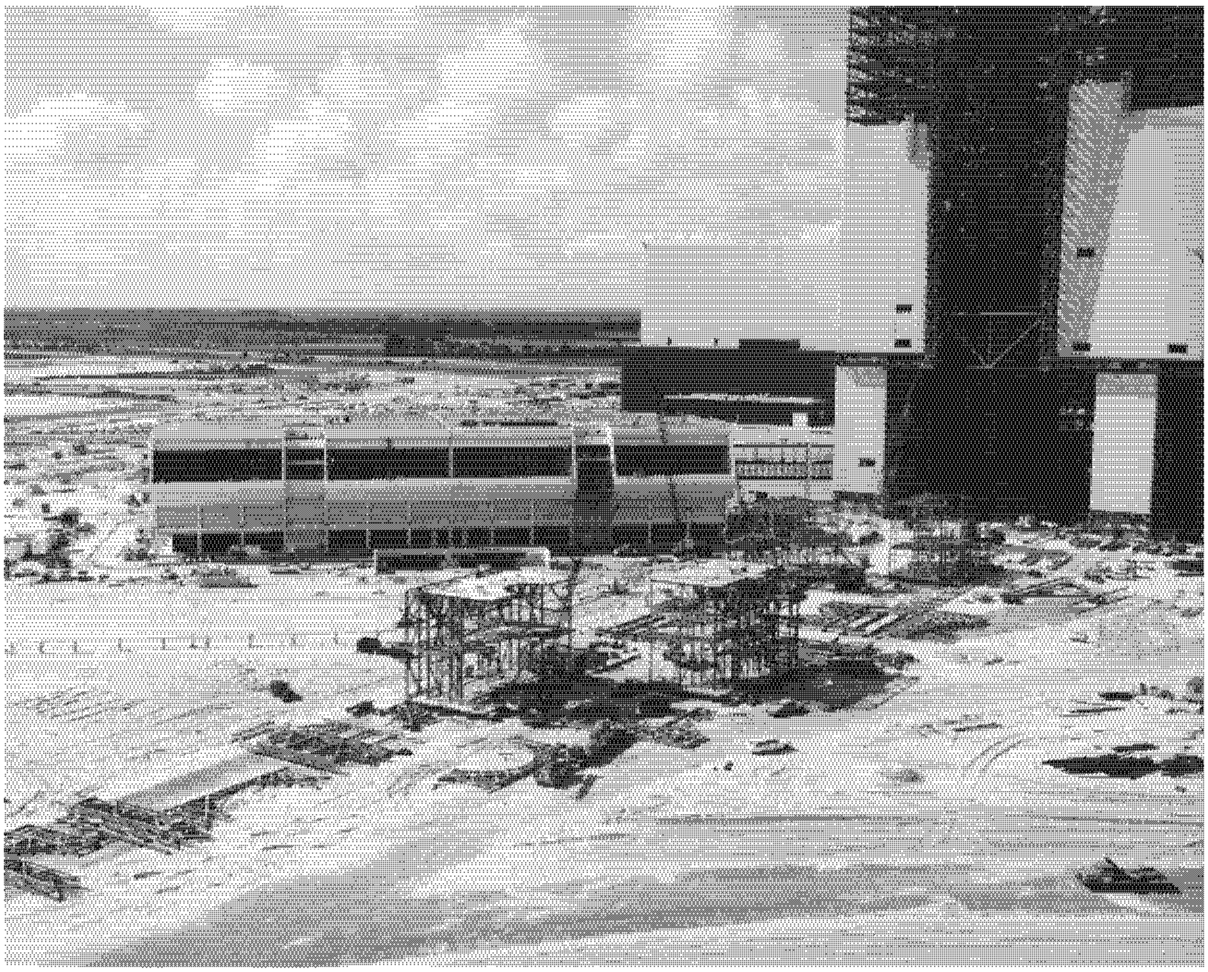

Photo A-2. Construction on Launch Control Center and Vehicle Assembly Building Work Platforms, Complex 39, February 11, 1965.
Source: John F. Kennedy Space Center Archives, 100-KSC-65C-990.

Photo A-3. Construction on Launch Control Center and Vehicle Assembly Building Work Platforms, Complex 39, March 11, 1965.
Source: John F. Kennedy Space Center Archives, 100-KSC-65C-1440.

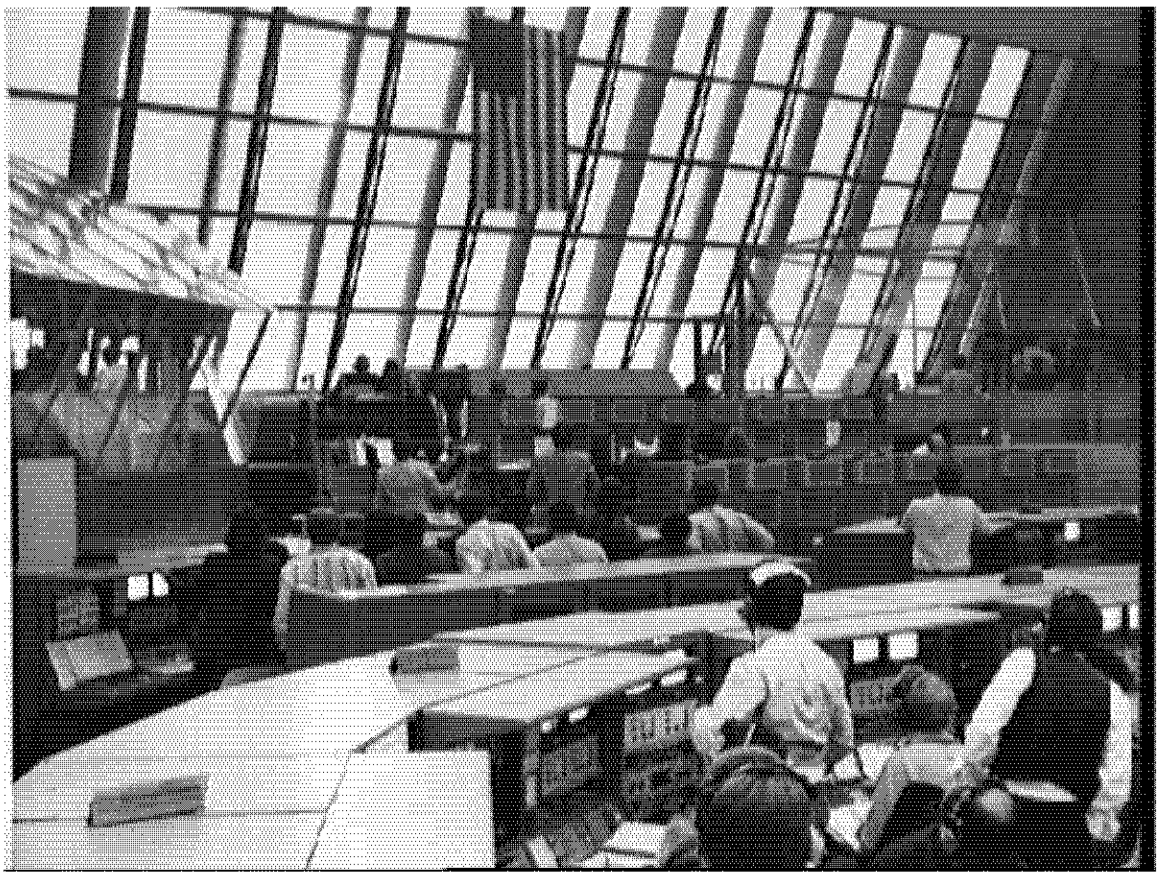

Photo A-4. Launch Control Center, Firing Room 1 during STS-32 launch, February 24, 1990. Source: Lyndon B. Johnson Space Center, S90-29047, accessed via NASA Image Exchange (NIX) at http://nix.nasa.gov/).